Health Effects of Shift Work

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More than 13.5 million American workers, close to 20 percent of the work force, are assigned to evening or night shifts. In some industries such as automobile, petrochemical and textile manufacturing the proportion of shift workers is greater than 50 percent. As the popularity of shift work and other "alternative work schedules" grows, concern is increasing over the disturbance created in the lives of workers and their families by these economically and socially useful innovations. Twenty percent of workers are unable to tolerate shift work. Daily physiologic variations termed circadian rhythms *are interactive and require a high degree of phase relationship to produce subjective feelings of well-being. Disturbance of these activities, circadian desynchronization, whether from passage over time zones or from shift rotation, results in health effects such as disturbance of the quantity and quality of sleep, disturbance of gastrointestinal and other organ system activities, and aggravation of diseases such as diabetes mellitus, epilepsy and thyrotoxicosis. Worker selection can reduce the number of health problems resulting from shift work. The periodic examination of shift workers is recommended.*

When working time for American workers was reduced from a 12-hour day, six-day workweek to an 8-hour day, five-day workweek, many felt that the ideal in work scheduling had been achieved. Since then, a number of factors have caused management in business and industry to change the times when their employees work. The primary factor has been economic. The high cost of capital equipment and the need to compete in worldwide markets have forced many companies to operate 24 hours a day, requiring back-to-back or overlapping shifts that fill the 24-hour period. Technology has also played an important role in this change, because modern processes that require continuity, such as steelmaking, pulp and paper production, and petroleum operations, require workers to be on the job 24 hours a day. Transportation has been another contributing factor. In heavily populated business and manufacturing centers, many companies have opted for alternative schedules that permit workers to start their jobs at different times to diminish traffic congestion.

In recent years, more emphasis has been placed on the psychosocial needs of the worker so that more and more workers are being permitted to choose the hours and times when they wish to work. As a result of the foregoing factors, we now have several work scheduling alternatives: the eight-hour daylight schedule, permanent off-hour shifts, rotating shifts that change from daylight hours to evening to night periodically and schedules arranged according to the choice of the worker.

Although alternative work schedules are generally well received by workers, some epidemiologists, sociologists and health personnel have raised questions as to whether these work schedules cause physiological or psychological changes in the workers.

The Biological Clock

One of the most important questions asked with regard to work scheduling is whether shift or rotational schedules will affect the internal rhythms of the body—the body's biological clock.

All organisms function according to internal rhythms that are synchronized by such factors as light or dark, summer or winter, clock time or social stimuli. The synchronizers are called *Zeitgebers* (from the German meaning "time-givers"). In plants and animals, the primary synchronizer is light (or the absence of it). With humans, light is also a synchronizer, but a relatively weak one. The most important synchronizers for humans are the awareness of clock time and social interaction. For example, with transmeridian flight and the

Refer to: LaDou J: Health effects of shift work, *In* Occupational disease—New vistas for medicine. West J Med 1982 Dec; 137:525-530.

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resultant time changes, humans are desynchronized from their *Zeitgeber,* clock time; similarly, when cut off from social interaction with families or others, humans lose their *Zeitgeber.* In humans and most animals, the internal rhythms governed by the biological clock approximate a 24-hour period and consequently are called circadian rhythms (from the Latin *circa dies* meaning "about a day"). The knowledge we have of these rhythms has come from investigators working with animals or humans and (1) removing subjects entirely from the normal light/dark cycle, (2) lengthening either the light or dark cycle or (3) inverting the sleep/wake cycle.[1]

From such investigations, it has been determined that body temperature fluctuates according to a rhythm; the endocrine system changes rhythmically; the flow of urine is rhythmic; the absorption, effect, metabolism and excretion of many drugs are strongly rhythmic; and the cardiovascular, hematopoietic, respiratory, and autonomic nervous systems all exhibit rhythmic patterns.[2] When the phase of a synchronizer is shifted—for example, when the light/dark cycle is altered as in experimentation—the body rhythms either shift with the synchronizer or become desynchronized from the external environment (light, time, society) and tend to become desynchronized from each other. Thus, the body temperature rhythm may run on a different time schedule from the external synchronizers and from the endocrine or other systems.

Circadian Rhythms in Shift Workers

Rutenfranz and co-workers have concluded that "Perhaps the most important physiological problem regarding shift work, particularly shift work which includes night work, is the problem of the reentrainment [resynchronization] of physiological functions after a phase shift of working and sleeping times."[1] This conclusion has been supported by studies of animals[3] and humans under controlled environmental conditions.[4-6] In shift work, the waking and sleeping times are phase shifted while the dominant human *Zeitgebers* of clock awareness and social stimuli remain constant. When this situation occurs, difficulties may follow. Air travelers who pass through time zone changes experience the same problem.[7]

Laboratory experiments have indicated that shift schedules with single night shifts did not alter the circadian rhythm of body temperature significantly. However, in night shifts lasting from one to three weeks, there was a shift of phase in minimum body temperature, with the minimum shifting to the new sleep period after seven or more days.[1] Different physiologic functions reentrain at different rates. Phase shift of physiological functions with shift rotation approximate findings observed after transmeridian flight.[7,8] In general, a full day of recovery time is required for each hour of time zone change. This would suggest that a week is required to adjust the normal phase relationship of circadian rhythms after shift rotation.

Although the occupational medical community considers the physiological problems related to shift work to be of primary concern, shift workers themselves feel that psychosocial shifts create the greatest problems in their lives. Thus, they are more concerned with whether shift work will interfere with or disrupt family relations or their social lives. Consequently, any shift work arrangement designed to alleviate physiological problems may not be acceptable to the shift workers if it does not also take account of their family and social relations.

Shift Work and Health

The primary health risk factors of shift work are sleep disturbance and altered eating patterns.[1,2]

Sleep Disturbance

Sleep quantity and quality is often disrupted when the sleeping time is shifted from night to day. The length of time shift workers sleep is indicated by the following findings of Menzel: Morning shift workers average 7.5 hours of sleep and afternoon shift workers average 8.5 hours, but night shift workers average only about 4 to 6 hours.[9] It has also been found that 50 percent of day shift workers sleep seven to eight hours, but only 15 percent of night shift workers sleep that long.[10] Similarly, other investigators have found the mean length of night sleep to be 7.55 hours and the mean length of day sleep to be 5.56 hours, with the shortest length of sleep occurring in people who go to sleep at the end of the night (5.45 hours).[11,12] It is generally found that day sleep lasts no longer than seven hours.[13-15] Of course, the hours of sleep needed differ by person and by age because sleep requirements lessen as one grows older. Nonetheless, Rutenfranz and co-workers concluded that all persons need more sleep time than is possible with night shift work.[16]

Sleep problems in shift workers occur primarily because the sleeping period is transferred to a time of day that is not conducive to sleep either in terms of circadian rhythms or environmental conditions. In the latter regard, the principal complaints of shift workers is that their sleep is disturbed by noises from children and traffic.[16-20] Investigations have shown that sleep disturbances are reported by workers as follows:[21]

- day workers, 15 percent to 20 percent;
- shift workers not working night shifts, 5 percent;
- night shift workers, 10 percent to 80 percent;
- permanent night shift workers, 60 percent;
- former night shift workers during night shift scheduling, 90 percent;
- former night shift workers during new day shift schedules, less than 20 percent.

When Thiis-Evensen surveyed 9,000 shift workers, he found that 20 percent of the workers suffered from lack of sleep, with the major complaint being disturbance from noise.[22] Of those who had to sleep between 7 AM and 7 PM, 78.8 percent complained of noise, with frequent sources being children, road traffic, telephone ringing and aircraft. When the same subjects slept during the night, there were no complaints about children's

noise or telephones ringing, of course, but complaints continued, although to a much lesser degree, about noise from road traffic and aircraft. Thus, it is evident that night shift workers experience greater problems with sleep disturbance than other workers. Environmental conditions play an important role in this problem. Workers living on well-traveled roads or near airports and in homes that are not well insulated against noise are particularly subject to sleep disturbance.

The quality of sleep is also affected by night shift work. The quality of sleep is generally accepted to be indicated by the different sleep stages that have been identified by electroencephalograms.[23] There are five sleep stages: stages I, II, III, IV and REM (rapid eye movement), which follow each other successively. It has been determined that sleep time is divided 4.4 percent to 5.4 percent in stage I, 48.7 percent to 51.2 percent in stage II, 7.7 percent to 10.1 percent in stage III, 11.2 percent to 13.2 percent in stage IV, and 22.9 percent to 24.1 percent in REM sleep.[24,25] Age does not appear to lessen REM sleep, particularly during the normal working years, but from the mid-30s on, stage IV sleep decreases while stage I sleep increases.[26,27] If sleep disturbances occur in stage II or the REM stage, the quality of the sleep is substantially impaired.

Impairments in both the quantity and quality of sleep can impair well-being and, if the impairments are severe, can affect work performance and safety cognizance. Workers who have problems in any of these areas should be questioned about the quantity and quality of their sleep and the environment in which they sleep. Night shift workers should be particularly studied in this regard; if there is evidence of severe sleep problems, they may need to be transferred to another shift.

Disturbance of Eating Patterns

Shift workers, particularly night shift workers, have a higher incidence of gastrointestinal problems than day workers.[22,28-30] The frequency of digestive problems among shift workers suggests that eating habits may play an important role. Appetite disturbances have been found to occur as follows in the various worker groups:[21]

- day workers, less than 5 percent;
- shift workers not on night shifts, less than 5 percent;
- shift workers on night shifts, 35 percent to 75 percent;
- permanent night shift workers, 50 percent.

Disturbances in appetite and gastrointestinal problems in shift workers, particularly permanent night shift workers, may occur because of the change in normal eating times, the difficulty of obtaining hot, nutritious meals during the night shift and the inability to have social contact during mealtimes with family or friends. Although calorie intake is not lessened in shift workers, appetite disturbances may be related to a dislike of eating outside the customary social environment. Sleep disturbances may also play a part.

The foregoing factors can result in gastrointestinal complaints although other conditions, such as personality, stress on the job, coffee drinking, family problems and social difficulties must also be taken into account. The incidence of gastrointestinal problems in shift workers is as follows:[21]

- day workers, 10 percent to 25 percent;
- shift workers not on night shifts, about 17 percent;
- shift workers on night shift, 5 percent to 35 percent;
- permanent night shift workers, about 50 percent;
- former shift workers who left shift work for health reasons, 30 percent to 50 percent.

The foregoing figures do not show a clear differentiation of gastrointestinal complaints among various groups of workers. Nonetheless, shift workers with gastrointestinal difficulties warrant medical attention and workers with more serious illnesses may need to be transferred to permanent daytime work schedules.

Other Health Problems

Diabetes mellitus and epilepsy are health problems that can be exacerbated by shift work since both have been found to be rhythmic in nature.[2]

Periodic variations have been observed in persons with diabetes mellitus, including 24-hour rhythms in the excretion of citric acid and β-hydroxybutyric acid and the production of ammonia in the kidney.[31] These rhythms may affect the timing of insulin administration. Furthermore, in diabetic persons, regular food intake and correct timing of medication are highly important and cannot always be achieved under shift work conditions.[1]

Epileptic seizures have been found to follow a rhythmic pattern in terms of the time of day when they occur.[32] In one study of 110 epileptic patients, the investigators observed that the incidence of seizures rose steadily from 3 AM to a peak between 6 AM and 7 AM, with the second highest incidence being between 10 PM and 12 midnight.[33] A later study concluded that night shift workers suffering from epilepsy tended to have seizures during their customary sleep time.[34] Sleep disturbance, a primary problem of shift work, is also believed to increase the incidence of epileptic seizuers.[35]

Psychosocial Aspects of Shift Work

Shift work may result in psychosocial problems that can sometimes be more difficult than physiological problems. There are fewer difficulties when a shift worker socializes primarily with other shift workers or lives in a community where shift work is the predominant work form. If that is not the case, shift workers may feel isolated from friends and community because participation in social and community activities is limited by the hours worked. Family relationships also present a problem because other members of the family often live according to a different work/sleep schedule, particularly if there are minor children.

Shift workers complain more frequently of sex-related problems and disturbed relationships with friends.[1] However, shift work can have some positive psycho-

social effects. A shift worker, of course, has more leisure time during the day to spend with family or friends if the latter are not working during the daytime hours. Yet it should be noted that this free time accrues not only from the shift system, but also from the reduced amount of sleep experienced by shift workers. Many shift workers, however, resent the fact that they cannot attend theater or sports events or even watch their favorite television programs, and some are now requesting that the timing of union meetings, religious services, television programs, shops and libraries be adapted to their working needs.[1]

Performance and Safety in Shift Work

Performance on the job and safety awareness are important considerations with regard to shift work.

To date, the evidence as to whether or not performance is degraded among shift workers is inconclusive. It is well known that human performance follows circadian patterns.[36-38] Thus, it would appear that the same type of work undertaken by the same person at different times of the day would result in different outputs. It is difficult to undertake a conclusive investigation of work performance and decrements created by shift work. One study has concluded that performance differs between morning-oriented and evening-oriented persons.[39] This study suggested that morning-oriented persons performed well in the morning hours but exhibited performance decrements during the evening hours, while evening-oriented persons performed poorly in the morning hours but considerably better at night. This conclusion suggests the value of determining morning or evening orientation as a shift assignment consideration.

Safety among shift workers is another inconclusive area of research. One team of investigators, in a study of vigilance efficiency, found that differences by the time of day were statistically significant in only a minority of the cases.[40]

Circadian variations in accident occurrences have been investigated, but the findings were contradictory. In one survey of 11,000 workers in the mining and steel industries, accident rates were found to be higher in the morning and afternoon shifts than the night shift, but accidents during the night shift were more serious.[41] Some investigators have concluded that two accident peaks occur during daytime hours, one at 10 AM and the other at 4 PM.[42-44] Conversely, other investigators found that daytime accidents, when grouped by 15-minute periods, showed peak occurrence times at 9:30 AM, 11:45 AM and 2 PM.[45] Studies attempting to relate accidents to rest breaks were also ambiguous in their findings.

Future studies should take into account the temperament and background of the persons involved; environmental factors, such as heat and cold, whether the individual has had accidents away from work and the particular time during the shift when the accident occurred.[46]

Optimal Shift Work Scheduling

There is no optimal shift work schedule that would meet the needs of all production operations or the living and working conditions of all shift workers. It has been suggested that the following criteria are useful in judging the appropriateness of a shift schedule:[1]

- Single night shifts are to be preferred over consecutive night shifts because the former do not alter the circadian rhythms significantly whereas seven nights of shift work are required to reentrain these rhythms.[47-49] Similarly, for psychosocial reasons, shift workers should work no longer than one week on the shift without free time or a change of shift.
- Each night shift should be followed by at least 24 hours of free time. Sleep deprivation is the primary complaint of shift workers, and this problem may constitute a risk factor when extended over several days. To offset the harmful effects of sleep deprivation, shift workers should be given a suitable recovery period after each shift.[50,51] Moreover, a 24-hour break should be allowed for morning shifts where workers must start so early that their sleep is likewise impaired.
- The length of the shift should be based on the type of work to be done. Thus, shifts involving light work can be longer than those that require heavy physical or difficult mental work, but in neither case should shifts be longer than eight hours. The "compressed workweek," with its workdays of 10 and 12 hours, is increasingly stressful to older workers.
- The length of the shift cycle should not be too long (4 weeks, for example, is better than 40 weeks).[1,52] Moreover, if a rotational system is used, the shift should be rotated regularly so that workers can plan their family and social lives. A recent study found that rotation every 21 days was preferred over weekly rotation by the workers, and that rotation by "phase delay," from day to swing to night shift, combined with the longer rotation schedule, improved subjective estimates of worker satisfaction and health, resulting also in a decrease in employee turnover and an increase in worker productivity.[53]
- Workers on permanent shift work should be given as many free weekends as possible so that they may participate in at least some family and social functions.

Selection of Shift Workers and Health Monitoring

Workers should be carefully reviewed before being assigned to shift work because 20 percent of the working population cannot tolerate shift work.[1] There are few clear-cut criteria for selecting shift workers. Many areas, such as health effects and performance, require a great deal more research. However, present knowledge indicates that there are those persons who should not be assigned to shift work, and plant safety and health personnel should give careful attention to the following categories of workers:

- New employees younger than 25 years of age (particularly if living alone) and older than 50 should be selected with caution for shift work. If the over-50 worker

is experienced and well adapted to shift work, he or she should be allowed to continue shift work on a voluntary basis. A worker may be chronologically 50, but physiologically many years younger.

- Persons with a history of gastrointestinal disorders should not be assigned to shift work, since gastrointestinal function may be affected by the psychophysiological problems inherent in shift work, as well as the disruption of meal times and frequent inability to obtain hot, nutritious meals at off hours.
- Diabetic persons and those with thyrotoxicosis should not be assigned to shift work without careful medical monitoring because regular food intake needed by diabetic patients and appropriate therapeutic timing required by persons with either condition are difficult under shift work conditions.
- Those with epilepsy, similarly, should not be assigned to shift work without medical evaluation and continued attention because sleep deprivation increases the likelihood of seizures.
- People with sleep disturbance problems or emotional instability are poor candidates for shift work. These conditions are likely to worsen with circadian desynchronization.
- Workers who live in noisy areas, as on busy arterial streets or near airports, and those who have sleeping quarters that are poorly insulated against noise also are not good choices for shift work because they are more than likely to be deprived of sleep even under normal working conditions.

Shift workers should be given particular attention by the health personnel of their companies. A suggested program provides all potential shift workers with medical examinations before assignment to shift work, six months after assignment and regularly every two years thereafter. Shift workers older than 50, however, should be examined more frequently.

Conclusions

Study findings on shift work have been relatively inconclusive with regard to health, performance and safety effects of shift work scheduling. This is due to methodological limitations in field investigations, and is inconsistent with numerous clinical observations that shift work, particularly rotational shift work, is a significant source of occupational stress. In recent years the growing popularity of "alternative work schedules" has also resulted in significant increases in subjective health complaints and employee turnover for health-related reasons. These work schedules may, in time, result in aggravation of diseases whose circadian rhythmicity is affected by the circadian desynchronization resulting from shift rotation, sleep deprivation, prolonged work shift and a number of other variables. Age appears to increase the susceptibility of workers to the problems of circadian desynchronization. As the popularity of "alternative work schedules" grows, clinicians will need to consider the age of their worker patients, the demands of the occupation and the presence of such predisposing risk factors as sleep disturbance, emotional instability and diseases such as diabetes mellitus and epilepsy when asked to evaluate the prospect of shift work assignment.

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Medical Practice Questions

EDITOR'S NOTE: *From time to time medical practice questions from organizations with a legitimate interest in the information are referred to the Scientific Board by the Quality Care Review Commission of the California Medical Association. The opinions offered are based on training, experience and literature reviewed by specialists. These opinions are, however, informational only and should not be interpreted as directives, instructions or policy statements.*

Reconsideration of Biofeedback

QUESTION:

In your judgment, are there valid medical indications for the use of biofeedback?

If so, under what circumstances would biofeedback be accepted therapy?

OPINION:

In the opinion of the Advisory Panels on Internal Medicine and Neurology, biofeedback has legitimate use as part of a medical treatment plan. There are valid medical indications for the use of biofeedback for conditions such as chronic muscle contraction headaches, certain mixed headaches (of muscular and vascular origin), migraine, chronic pain syndromes of muscular or vascular origin, and other psychophysiologic states where excess tension, stress and high autonomic arousal are part of the syndrome. Modest results have been achieved in patients with moderate hypertension.

Biofeedback for neuromuscular reeducation and organic disease problems such as convulsive states and ectopic beats should be considered investigational. Its role as an adjunct to more established management remains unknown at this time.

Biofeedback is only as effective as the skill of the therapist and the ability of the patient to learn the techniques of relaxation. Because the treatment works in a limited number of patients and has the potential for overuse, candidates for therapy must be well selected. As significant underlying psychological problems may arise during the course of therapy, biofeedback practitioners should be highly trained in the fields of psychology and counseling.